

NOvA APD Cooling Water Update

William Gilbert

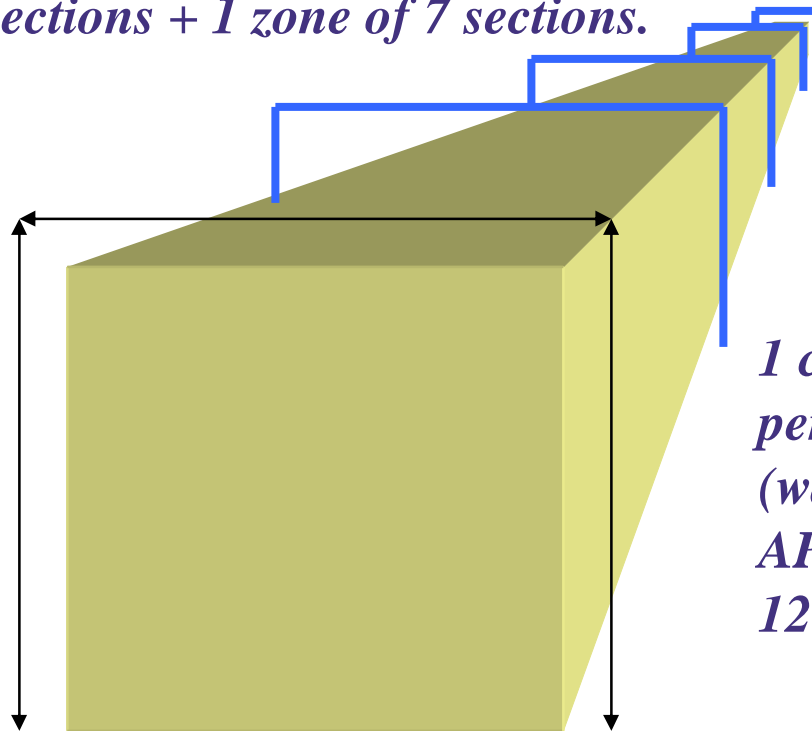
University of Minnesota

Cooling System Zones & Dimensions

*4 cooling zones along the length of the detector
supplied by chilled water at 48 °F supplied by FESS.*

☐ *3 zones of 8 sections + 1 zone of 7 sections.*

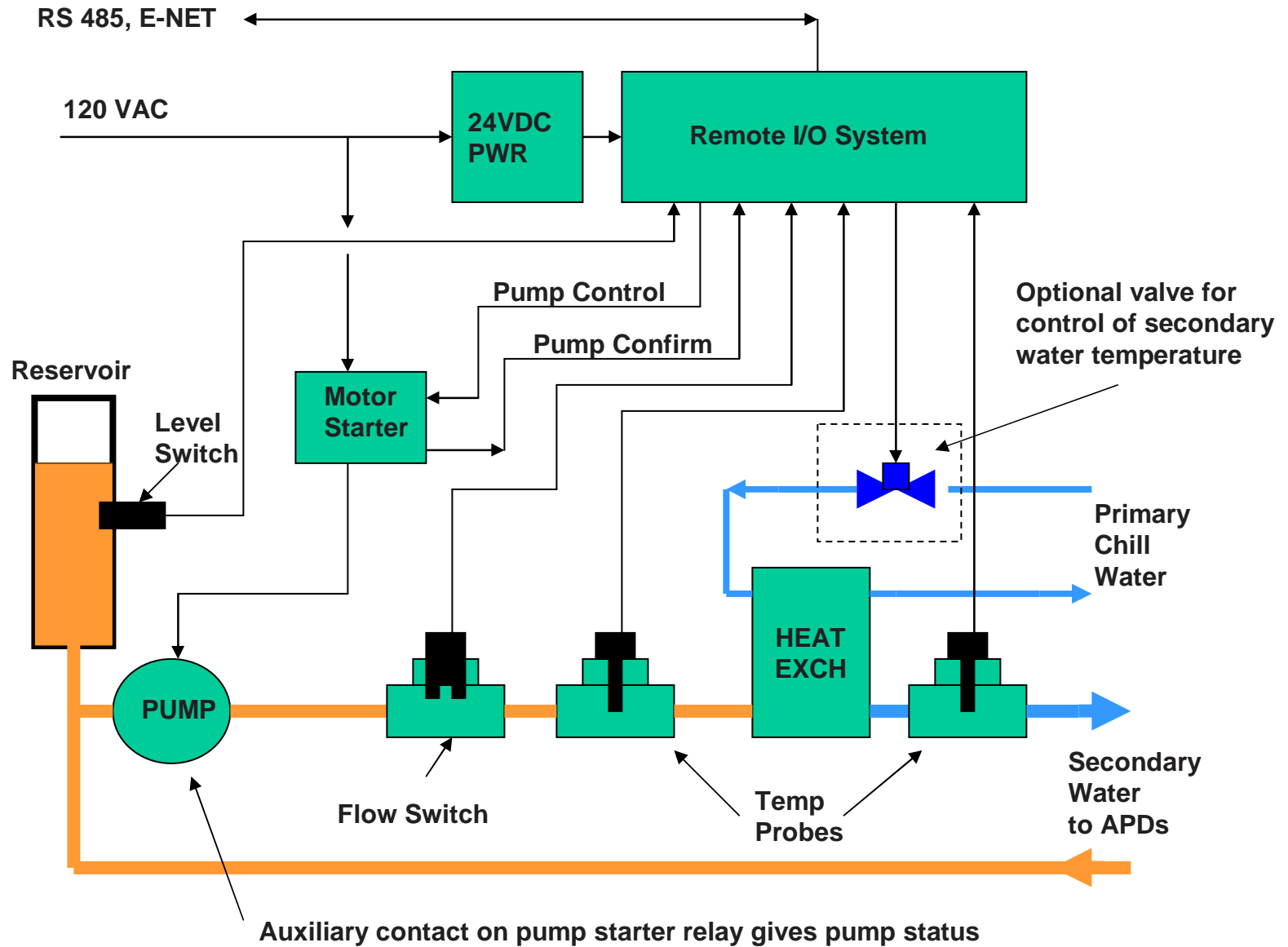
*12 rows
of detectors
each face*



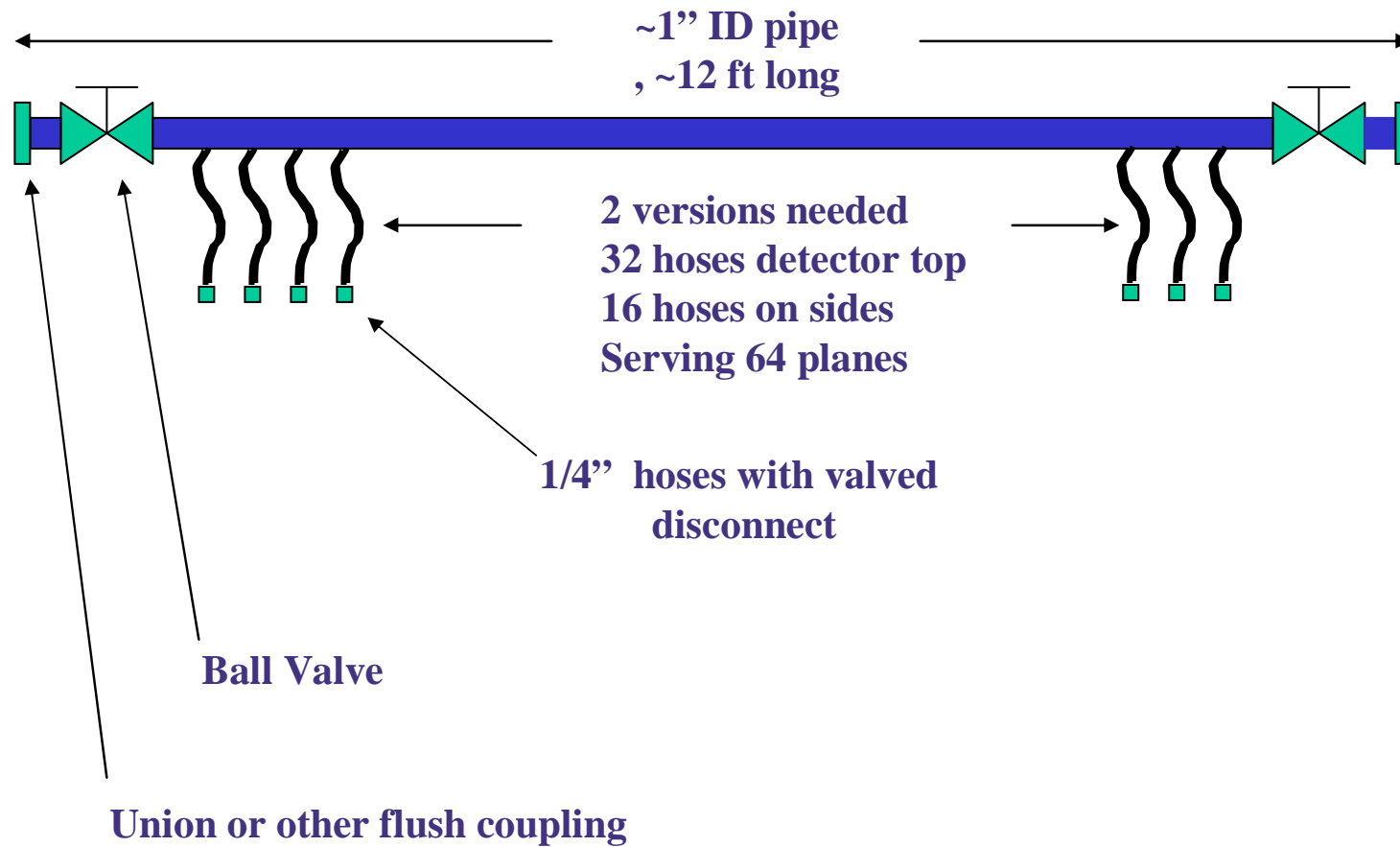
*1 cooling loop per row,
per zone,
(water from heat exch to
APDs)*

*12 row x 3 face x 4 zones
= 144 secondary loops*

Pump Unit & Instrumentation



NOVA Cooling Manifold Section



Single Loop Heat Calculations

$$\begin{aligned} 5\text{w per APD module} \times 217\text{units} &= 1085\text{w} \\ \text{Assume (guess) heat pickup in pipes, etc} &= 1085\text{w} \\ \text{Total} &= 2170\text{w} \end{aligned}$$

$$\begin{aligned} \text{Loop delta T} &= Q(\text{watts}) / [263 \times \text{Flow(GPM)}] \\ &= 2170\text{w} / [263 \times 6.87\text{GPM}] \\ &= 1.2 \text{ degC} \end{aligned}$$

$$\begin{aligned} \text{ITD} &= \text{initial temp difference of fluids entering heat exchanger} \\ &= (\text{APD water} + \text{del T}) - \text{FESS chilled water} \\ &= (15 \text{ degC} + 1.2\text{deg C}) - 8.9 \text{ degC} = 7.3 \text{ deg C} \end{aligned}$$

$$Q / \text{ITD for this flow \& load} = 2170\text{w} / 7.3 \text{ degC} = 297$$

Compare to high limit value from Lytron chart for this flow rate, 800
297 is much lower, so this is well within capacity of LL520!

Use Macroflow?

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MacroFlow For Electronics Cooling

Capabilities

• Use in Thermal Design

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Technique of FNM

Technical Publications

Use of MacroFlow in Thermal Design

MacroFlow is ideally suited for system-level thermal design during the Conceptual Design stage. Its object-oriented nature enables quick construction of flow networks of cooling systems and the powerful solution method enables rapid analysis. Thus, many different system layouts, "what if" studies, and contingencies such as fan failure can be evaluated very quickly for arriving at few good system-level design early in the design cycle.

MacroFlow is a productivity tool. Its use results in significantly shorter design cycles, better product quality, and reduces the time to market.

Construction of Networks for Electronics System	Types of Cooling Systems Designed Using MacroFlow
Benefits and Limitations of MacroFlow	The Enhanced Design Cycle

Macroflow example

Electronic cooling system via manifold distribution 30 elements X 4 rows, reverse return

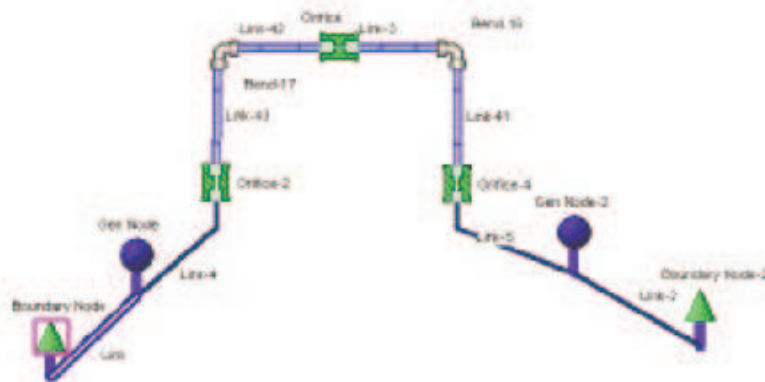


Figure 4. One Branch of the FNM, analogous to one LCM

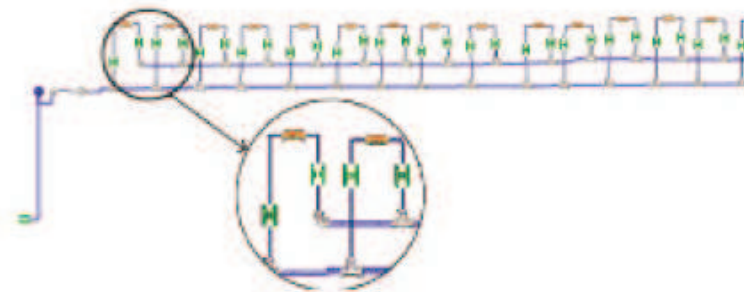


Figure 7. One Row of the FNM, analogous to a section of one row of the manifold

Complete System

The complete system consists of several rows of LCMs

Macroflow example part 2

Looks very similar

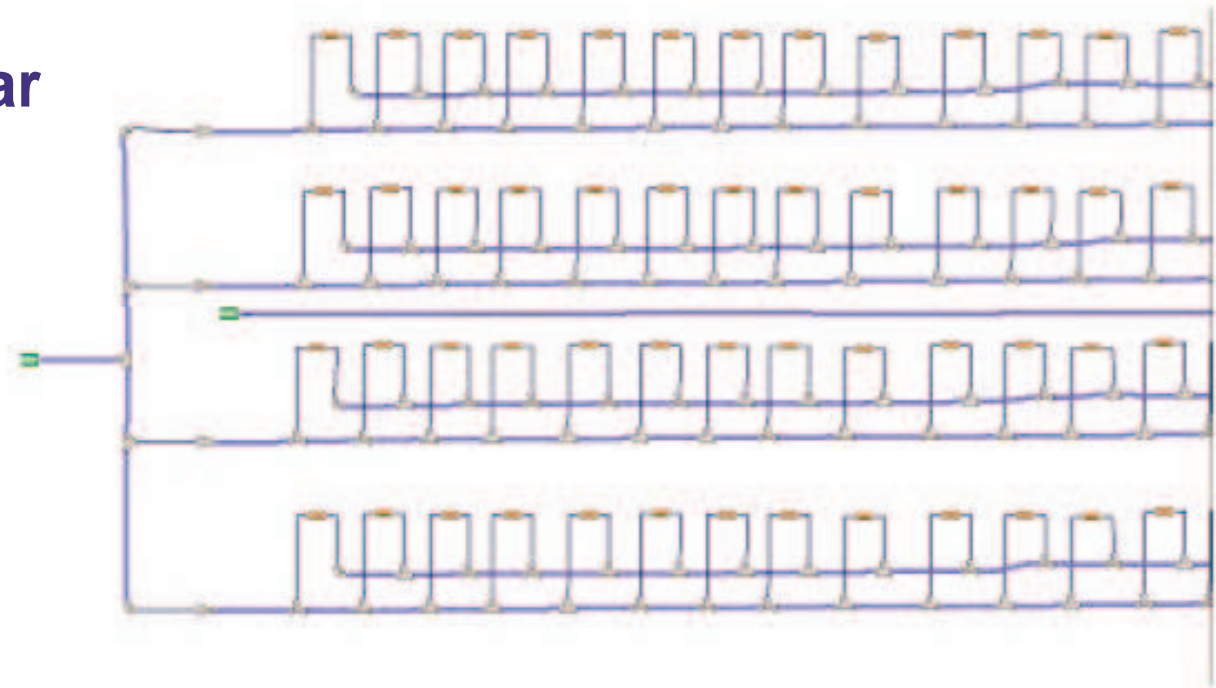


Figure 8. A Section of the Complete System

Loop Volume

Using 1" dia manifolds, pipes, and 25k ton dimensions,

Single loop water volume = 2960 cu in
= 12.8 gal
= 107 lb

Weight of water system, guess at 2x this, ~200lbs
Total length of system is ~100 feet, so 2lbs/ft, 24lbs/span
But, it's just plastic, so we will need several supports along the span,
probably every 3-4ft.

Total water volume, 144 loops, = 1843 gal
= 15400 lb

Old Loop Cost Estimate

SWAG cost estimate for loops on detector top, side loops a bit lower:

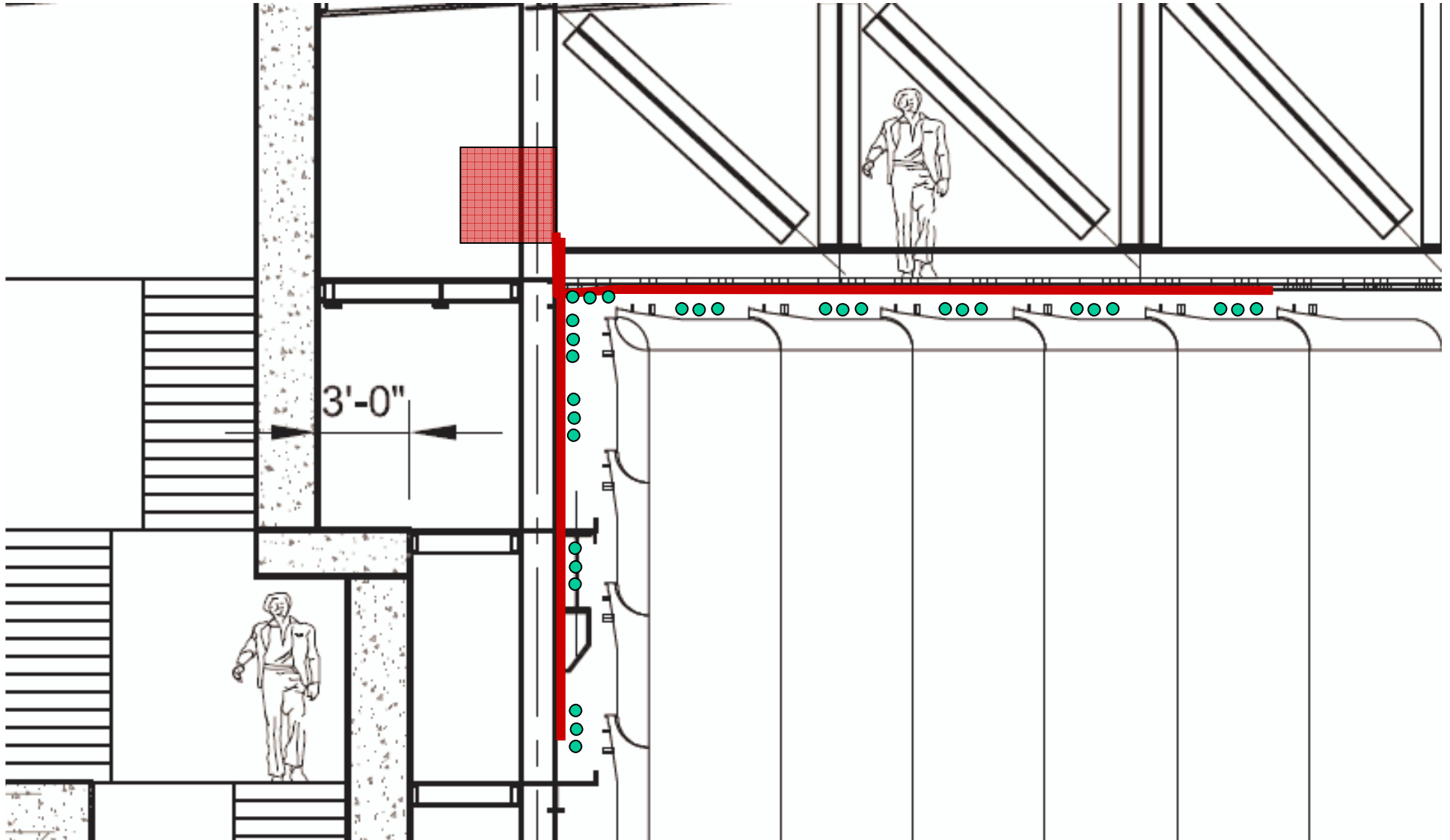
1	Pump 1/25hp bronze cast	\$ 150	\$ 150
1	Heat Exchanger (~LytronLL520)	\$ 200	\$ 200
16	Top manifold assembly	\$ 830	\$ 13280
1	Fluid Reservoir	\$ 50	\$ 50
1	Fluid level switch(float, capacitive, other)	\$ 80	\$ 80
2	Temp probes, RTD in welded SS fitting	\$ 50	\$ 100
1	Flow switch (~Omega FST-211-SPST)	\$ 160	\$ 160
1	enclosure	\$ 200	\$ 200
6	Remote I/O channels(2 temp, 1flow, 1 level, 1 pump status, 1 pump control)	\$ 200	\$ 1200
x	Misc pipe, wire, cable	\$ 100	\$ 100
24	man-hours assembly: mount 8 manifold sections make 512 quick connects mount & connect pump & other components install wire duct, field wiring, fill, test etc.	\$ 50	\$ 1200
	Total		\$ 16720

New Loop Cost Estimate

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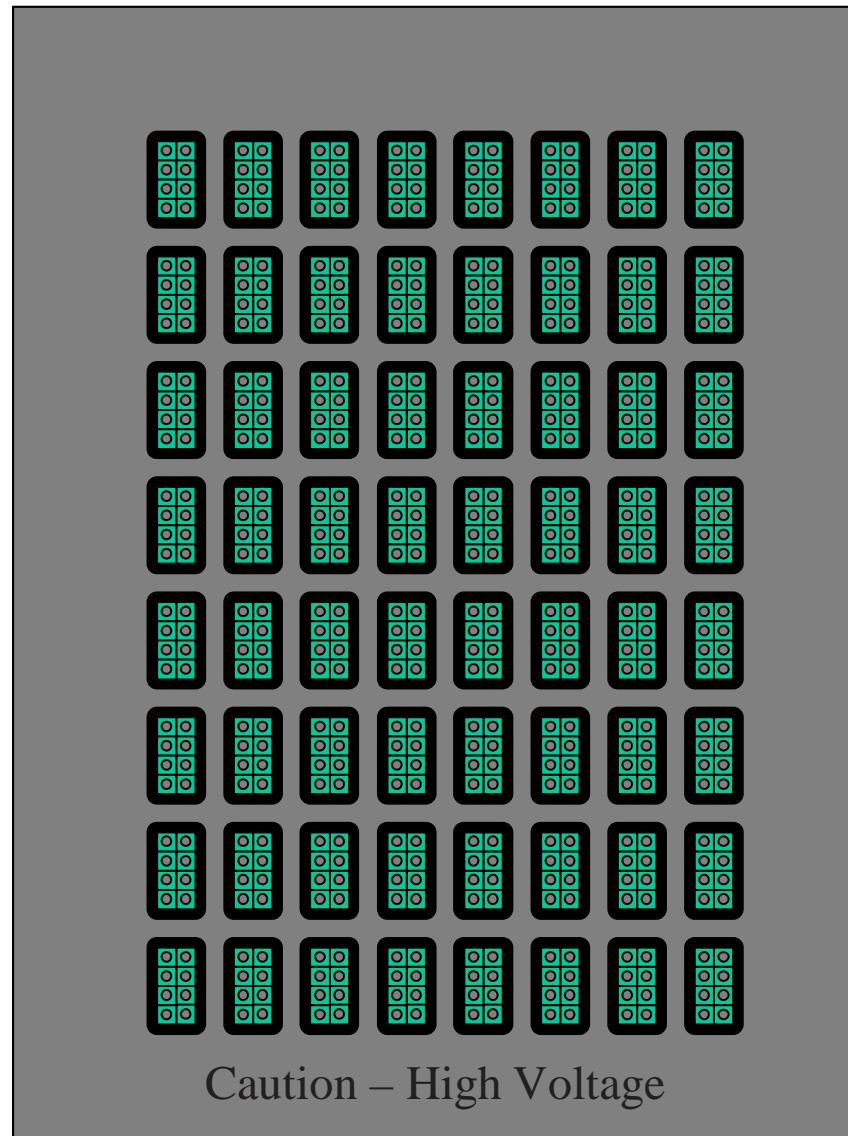
1	Pump 1/6 hp bronze cast	\$ 300	\$ 300
1	Heat Exchanger (~LytronLL520)	\$ 200	\$ 200
14	Top manifold assembly	\$ 780	\$ 10920
1	Fluid Reservoir	\$ 50	\$ 50
1	Fluid level switch(float, capacitive, other)	\$ 80	\$ 80
2	Temp probes, RTD in welded SS fitting	\$ 50	\$ 100
1	Flow switch (~Omega FST-211-SPST)	\$ 160	\$ 160
1	enclosure	\$ 200	\$ 200
6	Remote I/O channels(2 temp, 1flow, 1 level, 1 pump status, 1 pump control)	\$ 200	\$ 1200
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	Total		\$ 14510

Utilities Version A



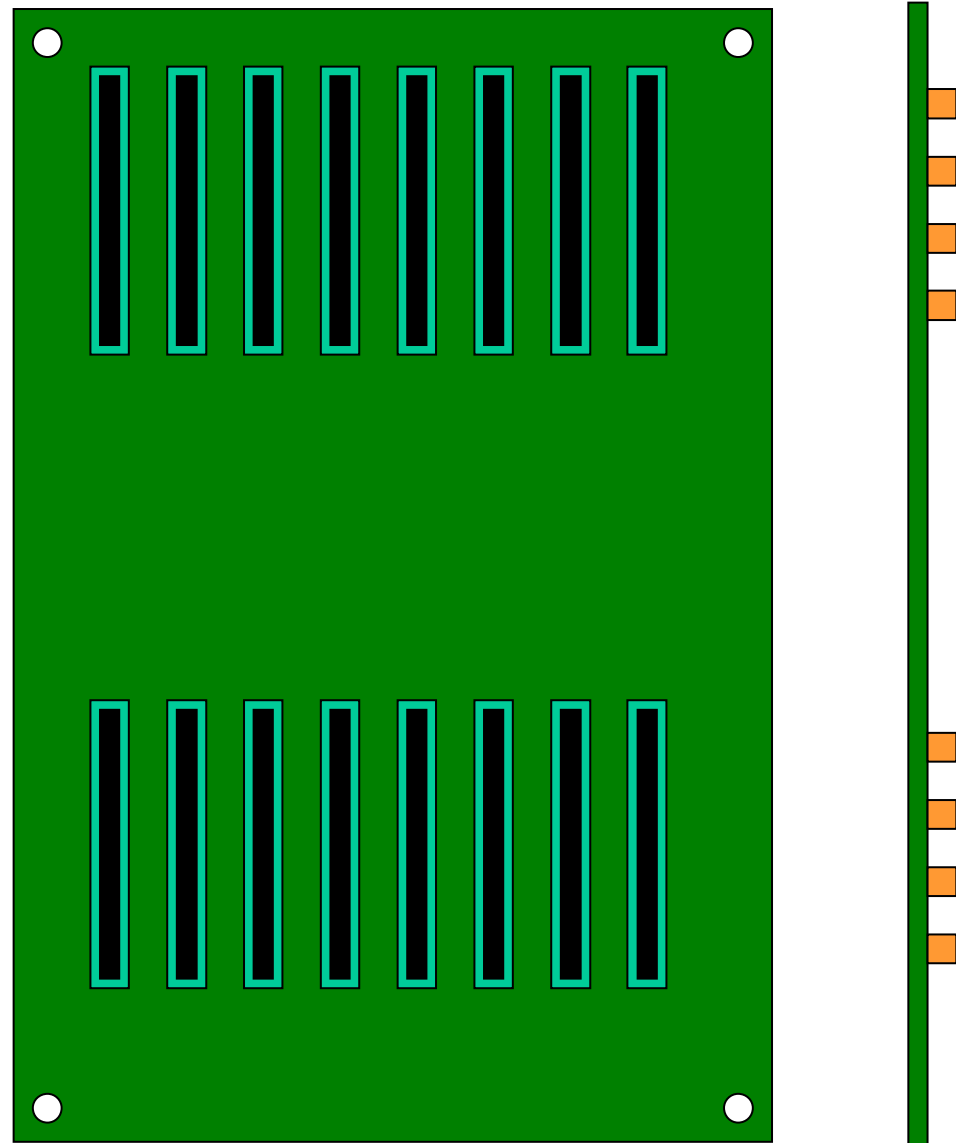
Distribution Box

- Completed Distribution Box
- Card Cage not shown
- Power Dist Boxes
 - \$362k



Power Backplane

- Backplane with Cu bus bars



Top Power/Data

High Voltage
Low Voltage
Local redistribution
(1.7m avg. cable length)

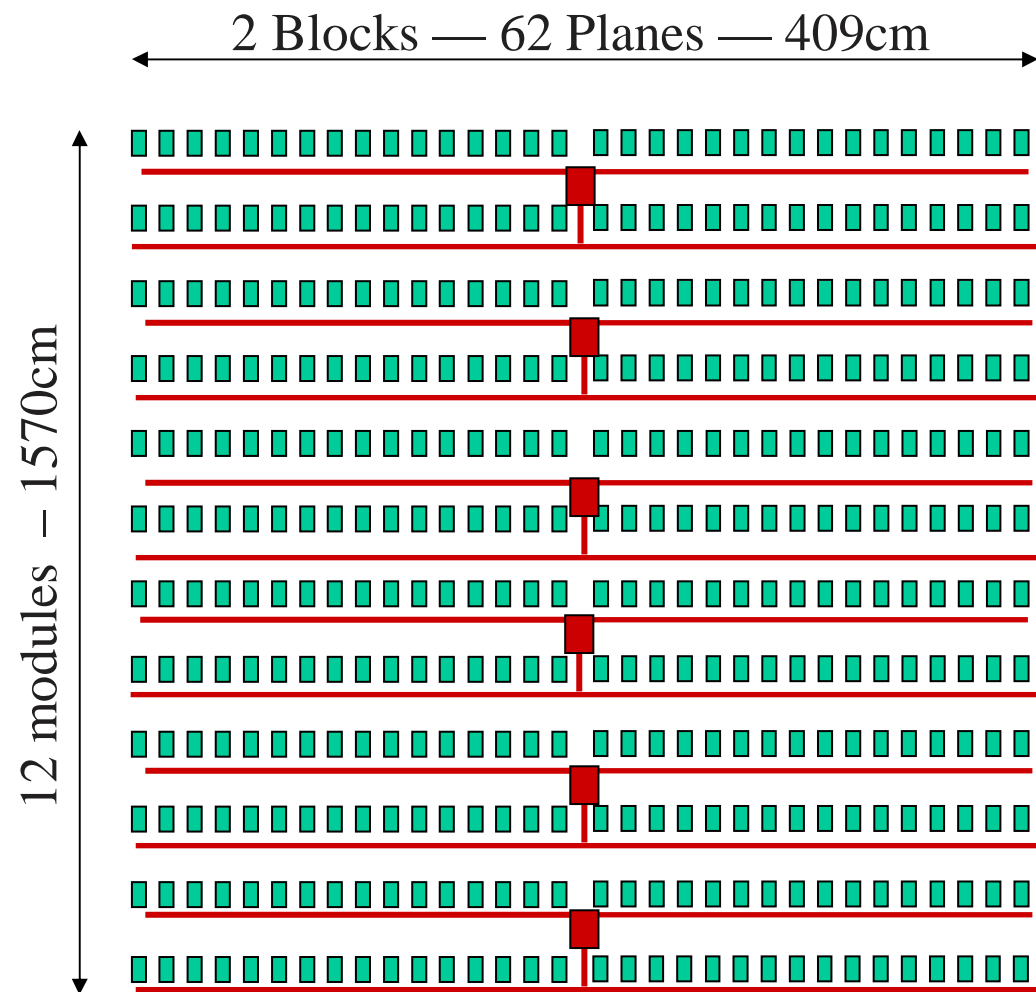
Each Power Distribution
Box powers 64 boxes

DAQ services along same
route from neighbor box

~2"x6" Cable Tray along
Detector

■ Power Distribution Box

■ APD readout box



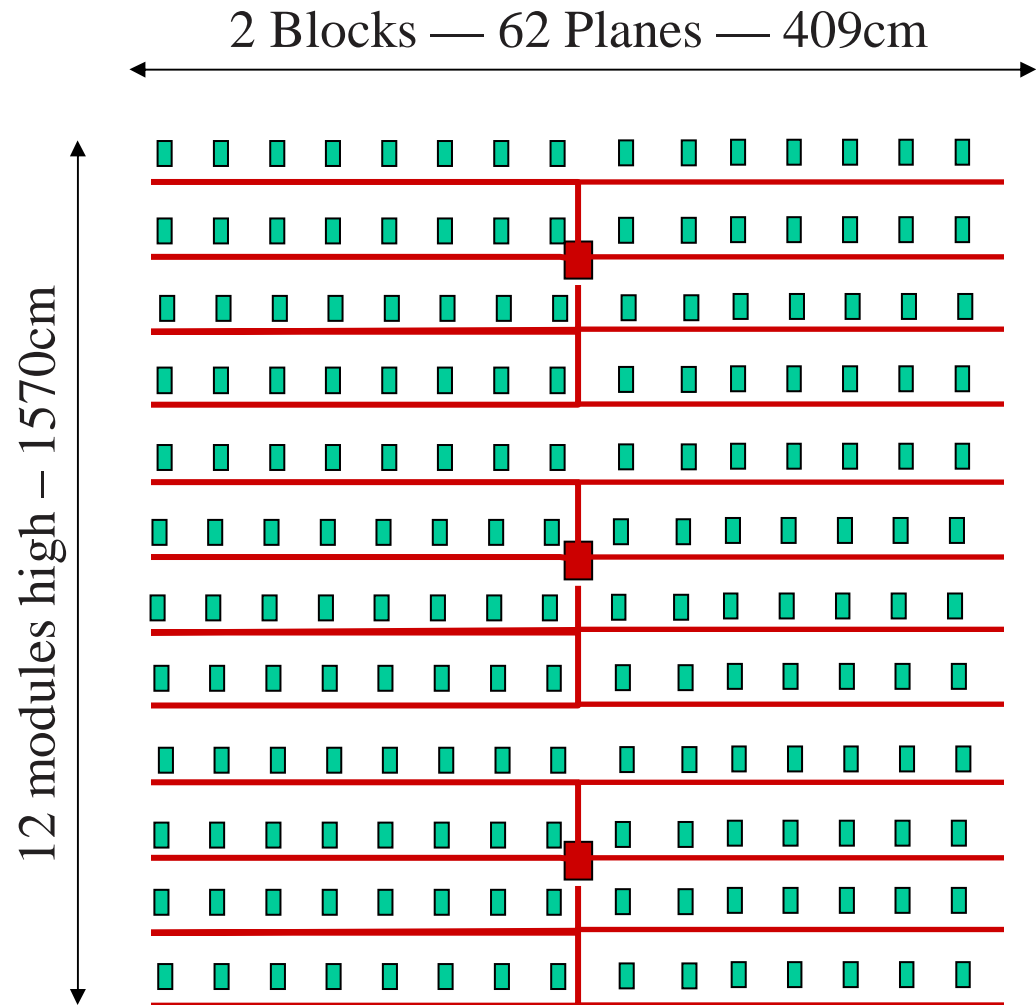
Side Power/Data

High Voltage
Low Voltage
Local redistribution
(2.3m avg. cable length)

Each Power Distribution Box
powers 60 boxes

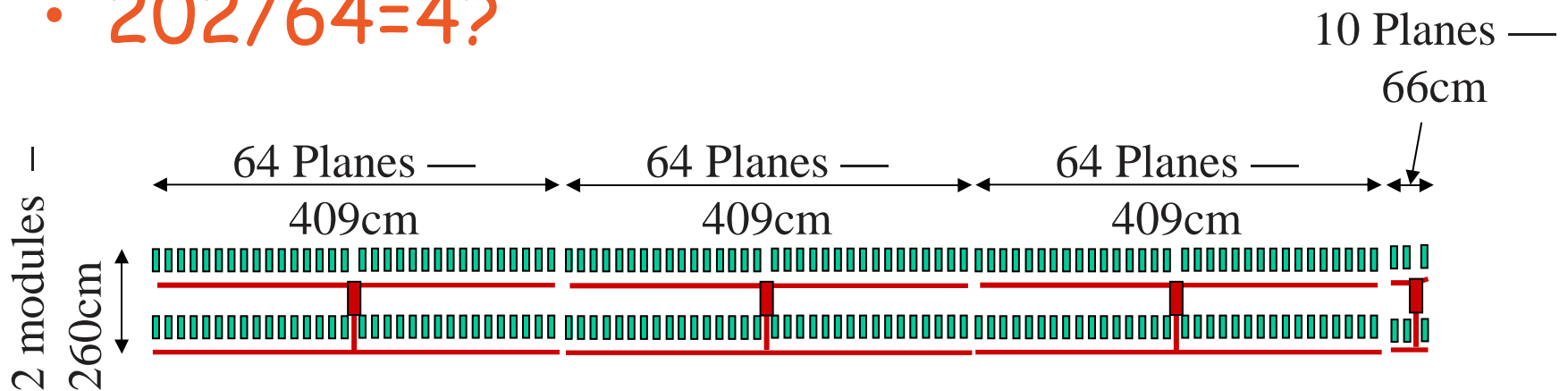
DAQ services along same
route

- Power Distribution Box
- APD readout box



IPND Top Power

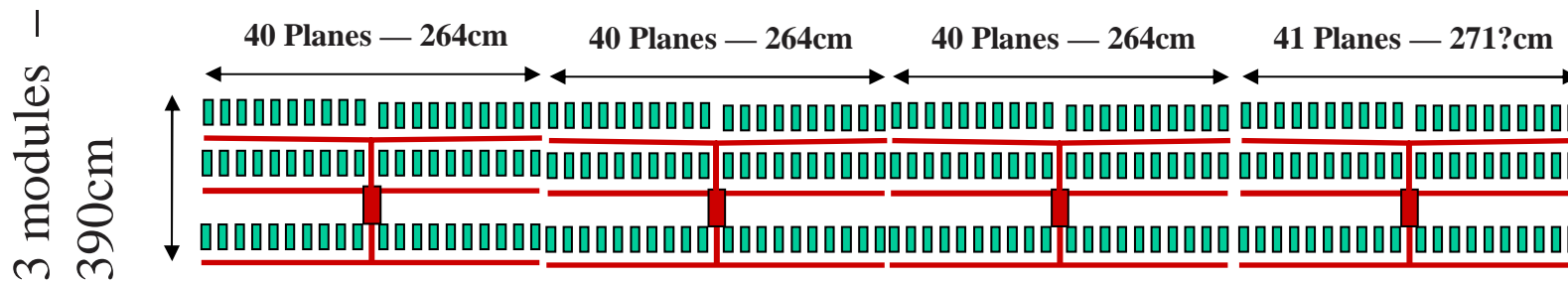
- Distribution to 202 modules
- $202/64=4?$



- Can we drop 10 planes?
- Better Distribution with 50/50/50/52
 - Special channel map for DAQ

IPND Side Power

- Distribution to 303 modules
- $303/64=5?$
- $60/60/60/63$



Cable loading weights

- Largest weight of cables
 - DAQ 0.8lb/ft
 - Power 1.5lb/ft
 - TOTAL 2.3lbs/ft
- Cable tray weight
 - 1.4lb/ft (for 2x12 wire mesh)
 - Tray capacity 8.3lbs/ft
- Hang H2O from cable trays?

Comments/Questions

- Nothing here about readout box mounting
 - Will be working with Tom Chase to define mounts, box and mounting procedures
 - PLAN for box to fit within the plane of the module, avoiding interference issues
- How much space between detector and steel
- How much space around IPND/ND in ALL dimensions, top, side, front, back